

# Recovery, Reuse, and Recycling of Debris From the Demolition of the Grace and Pearman Bridges At Charleston, South Carolina

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**REFERENCE:** *Proceedings of the 2008 South Carolina Water Resources Conference*, held October 14-15, 2008 at the Charleston Area Event Center

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**Abstract.** The purpose of this paper is to demonstrate, promote and support the recovery, reuse, and recycling of demolition debris to reduce costs and benefit the environment. The project that is presented involves the simultaneous demolition of the Grace Memorial Bridge and the Silas N. Pearman Bridge in Charleston, SC, which connected the City of Charleston with the Town of Mount Pleasant. The project was successfully completed by Jay Cashman, Inc. /Testa Corp., A Joint Venture (the Joint Venture), and their subcontractors, one being Earth Tech, Inc. (Earth Tech).

The Joint Venture's bid for the design and demolition of the two bridges included an amount of 261,000 tons of reinforced concrete and structural steel to be recovered and reused or recycled. Records maintained by the Joint Venture indicate that 240,292 tons of reinforced concrete demolition debris was placed in 12 off shore artificial reefs, 5,286 tons of debris was used to create a new artificial reef adjacent to a new observation pier at Mount Pleasant, and 24,668 tons of structural steel was recycled, adding to a total of 270,246 tons. These numbers are based on weights and measurements that include some margin of error, and therefore are not 100% accurate. However, there is certainly close agreement between the amount of materials estimated to have been available for reuse and recycling from the demolition of the Grace and Pearman Bridges (261,000 tons), and the amount of materials recovered, reused and recycled from the demolition of these bridges (270,246 tons). A post demolition hydrographic survey, including bathymetric contour mapping, a side scan sonar survey, and mapping by magnetometers, was conducted for the underwater demolition area. The survey found that all parts of the Grace and Pearman Bridges were removed down to or below elevations required, and that the waterways were cleared of significant amounts of debris to the satisfaction of the Charleston District US Army Corps of Engineers (USACE) Commander. The only significant amounts of

debris known to remain are 1,063 tons of buried debris on Drum Island located between Charleston and Mount Pleasant, and approximately 56 tons of debris beneath the new observation pier at Mount Pleasant. This reef construction project was the largest in South Carolina's history based on tonnage. This project also included the largest number of reef deployments (50), and enhanced the largest number of reef sites of any project in South Carolina's history.

## INTRODUCTION

The Grace Memorial Bridge (Grace Bridge) spanning both Town Creek and the Cooper River in Charleston, South Carolina was constructed in 1929 to connect the City of Charleston with the Town of Mount Pleasant. The bridge consisted of a 20-foot deck width allowing for two 10-foot travel lanes and the superstructure consisted of two three-span cantilever trusses. The approaches were constructed of steel deck trusses and steel girders, and the bridge was approximately two miles in length. This bridge became functionally obsolete due to substandard lane widths, lack of shoulders, and the increased volume and weight of traffic. A ten-ton weight limit was posted on the Grace Bridge in 1979 and large, heavy vehicles were diverted to the reversible lane on the Pearman Bridge, when completed in 1966. The Grace Bridge was eventually restricted and posted for a five-ton weight limit.

The Silas N. Pearman Bridge (Pearman Bridge) with a deck width of 38 feet allowed for three 12-foot travel lanes. The Pearman Bridge superstructure consisted of two three-span cantilever trusses with the approaches constructed of steel plate and pre-stressed concrete girders with reinforced concrete deck slabs. The Pearman Bridge was located just downstream and ran roughly parallel to the Grace Bridge. This bridge became functionally obsolete because it was unable to efficiently handle the

ever-increasing volume of traffic. The new bridge that replaced the Grace and Pearman Bridges, the Arthur Ravenel Bridge (Ravenel Bridge) is a single-span cable stay bridge with eight 12-foot travel lanes, and a 12-foot pedestrian/bike lane located on the downstream side of the bridge. The Ravenel Bridge allows the current navigational channel to be widened to 1000 feet with a horizontal clearance between the two main span towers of 1,546 feet, and a vertical clearance at mean high water of 186 feet.

Prior to the demolition of the Grace and Pearman bridges, an Environmental Impact Statement (EIS) was prepared for the Federal Highway Administration (FHWA) and the South Carolina Department of Transportation (SCDOT) to address potential environmental concerns related to demolition of the old bridges. The Final EIS was followed by a Reevaluation, also commissioned by the FHWA and SCDOT. These studies concluded in 2001.

Additional reports dated December 16, 2003, *“Demolition of the Grace Memorial Bridge and the Silas N. Pearman Bridge, Charleston County South Carolina”*, prepared by HDR Engineering Inc., and a further report written in September, 2004 by Parsons, Brinkerhoff, Quade and Douglas presented more detailed recommendations regarding a “Combined Explosive and Reverse Engineering Approach”, and recommendations for surveying the river bottom to evaluate the success of demolition debris removal. The demolition project was bid in 2005, and completed by the Joint Venture, meeting or exceeding the project specifications.

This paper will present (1) background of the shipping channel, (2) requirements for debris removal, (3) aspects of the SCDNR Artificial reefs program, (4) a comparison of the quantities of material available for recycle and reuse with the quantities actually recovered, and (5) concluding thoughts.



**Figure 1 – Photo of the Ravenel, Grace and Pearman Bridges crossing the Cooper River.**

## BACKGROUND AND RELATED WORK

Charleston, SC has been among the top four busiest ports on the east coast of the United States for many years. In 2006, the Port of Charleston handled 1.96 million twenty-foot equivalent units (TEUs), down slightly from 1.98 million TEUs in 2005. Growth of the port is expected to continue as a result of the State Ports Authority plan to develop a facility at the former Charleston Naval Base.

Utilizing the 1998 FEIS as updated in 2001, the SCDOT undertook the construction of the new Ravenel Bridge, which opened to vehicular traffic in 2005. As shown in Figure 1, the Ravenel Bridge (bridge with tall towers) follows an alignment that crosses over the Grace and Pearman bridges in the vicinity of Drum Island and terminates in Charleston (foreground), and Mount Pleasant (background).

The currently maintained shipping channel through the Cooper River Bridges is 600 feet wide, and 50 feet deep, although the Pearman Bridge provided 700 feet of horizontal clearance and the Grace Bridge provided 1000 feet of horizontal clearance. In the future, the maintained channel is expected to be widened to 1000 feet and the shipping channel is expected to be dredged to a depth of 60 feet.

Demolition of the Grace and Pearman Bridges began within a month of the opening of the Ravenel Bridge. It was extremely critical to keep the shipping lanes open for business as much as possible throughout the demolition to allow port commerce to continue. The contract stated that the maximum period of time that the shipping lanes could be closed during demolition of the spans over the Cooper River was 24 hours.

## REQUIREMENTS FOR DEBRIS REMOVAL

The agencies with responsibilities related to the debris removal included the Coast Guard, US Army Corps of Engineers (USACE), the South Carolina Department of Transportation (SCDOT), the Federal Highways Administration, the South Carolina Department of Natural Resources (SCDNR), and the South Carolina Office of Ocean and Coastal Resource Management (OCRM).

The Coast Guard issued a permit for the construction of the new bridge on June 7, 2001. The permit required:

*“All parts of the existing to-be-replaced US 17 bridges across Town Creek, mile 3.19, not utilized in the new bridges shall be removed in their entirety. All parts of the existing to-be-replaced US 17 bridges across the Cooper River, mile 2.86, not utilized in the new bridges shall be removed down to or below an elevation 65.0 feet below mean low water within the limits of the proposed 1000-*

*foot channel. Both waterways shall be cleared to the satisfaction of the District Commander. A period of 180 days subsequent to the opening of the new bridges will be allowed for such removals and clearances."*

The criteria relating to the minimum depth requirements for removal of material at the various bridge piers was established in a letter from the SCDOT dated November 17, 2004, which says in part:

*"On October 21, 2004, a conference call was held between personnel from the U.S. Coast Guard (USCG) 7th District Miami Office, the Charleston District Marine Safety Office, the South Carolina Department of Transportation (SCDOT), and the Federal Highway Administration South Carolina Division. The call was held to reach agreement on the depth requirements that would be placed on removal of the existing bridge piers. As a result of the discussion, the following plan was developed that outlines the depths to which the structures will be removed and the specific areas where the removal will occur:*

*Within Town Creek, the bridge piers will be removed to an elevation five (5) feet below the existing river bottom.*

*To facilitate future dredging operations, the piers within the proposed 1000 ft. Cooper River channel will be removed to an elevation of minus sixty-five feet (-65), measured from Mean Low Water (MLW), which will be five (5) feet below the new channel bottom.*

*Outside the above two areas the bridge piers will be removed to a depth of two (2) feet below the existing ground elevation or river bottom, or charted depth, which ever is lower."*

A pre-demolition hydrographic survey was performed by another subcontractor, Collins Engineers who specializes in underwater engineering operations. Their task was to establish the river bottom elevations and hence the removal limits of bridge piers. Not surprisingly, the pre-demolition survey identified existing debris on the river bottom. None of that pre-existing debris was included in tonnage reported in this paper for estimated and actual debris associated with the bridge demolition.

The elevations to which pier removal was required were established via Transmittals from SCDOT to the Joint Venture. SCDOT approved those removal limits, and the USACE concurred with the SCDOT approved removal limits.

There are additional contractual requirements that, "piers within the future channel slopes shall be removed to a five-foot depth below an assumed 4:1 slope...", and the footings in the SC State Ports Authority property are to be removed to 4-feet below final ground elevation. The USACE Permit for the demolition project contains drawings showing regions called 'debris fields' and regions called 'no debris fields' (Exhibit 8e - ACE 404

Permit No 2004-1W-323 2 8 05). The intent of identifying the different types of debris fields is that the 'no debris fields' are areas where there is to be no debris remaining above established removal limits, and 'debris fields' are regions that may contain up to 5% of total debris, evenly distributed. Exhibit 8e was reviewed with the SCDOT and it was agreed that the intent of the Permit is to remove the debris to the established limits listed above. It was also understood that any "No Debris Field" may contain debris BELOW the removal limits. It was further understood that the SCDOT would create an artificial reef in the vicinity of Pier M6, where debris would be placed to a depth, "not more than 3-feet above the river bottom".

Section 3.13 of the Cooper River Bridge Demolition Re-evaluation, dated September 30, 2004 states,

*"Due to the nature of demolition there will be some residual debris that cannot be captured. This debris is considered part of a fill and must be permitted accordingly. The Department is estimating that 95% of the demolition debris can be captured. The resulting 5% that will remain at various locations throughout the debris field limits represents approximately 2,800 cubic yards of material. The demolition debris field will extend approximately 100 feet outside of the bridge limits and to the edge of the river. The contractor will be required to complete pre-construction and post-construction surveys of the bridge corridor to determine existing conditions and to determine the extent of any debris remaining after demolition. All debris removal will be completed to the satisfaction of the Charleston District Corps of Engineers."*

## ASPECTS OF THE DEPT OF NATURAL RESOURCES MARINE ARTIFICIAL REEF PROGRAM

All marine artificial reef development and management in the state of South Carolina is the responsibility of the South Carolina Department of Natural Resources. The SCDNR Marine Artificial Reef Program (MARF) serves as the primary coordinating authority in the state for these activities and holds all construction permits issued by the U.S. Army Corps of Engineers for reef development along the coast. Responsibilities of the program include reef planning, design, permitting, construction, monitoring, research, and marking. Marine artificial reef development by the SCDNR is carried out in accordance with the standards, procedures and goals established in the South Carolina Marine Artificial Reef Management Plan (1991) which, in turn, follows the guidelines set forth in the National Artificial Reef Plan (National Marine Fisheries Service, 1985). The SCDNR MARF currently manages

45 permitted artificial reef sites along the South Carolina coast. Marine artificial reefs are a type of fishery management tool in which manmade structures are intentionally placed on permitted sites on the ocean bottom to provide a solid foundation for the development of a natural marine reef community. Marine artificial reefs can be used for habitat enhancement, fisheries stock enhancement, the improvement of saltwater recreational and commercial fisheries, and recreational diving opportunities.

The state of South Carolina has traditionally relied upon the donation of suitable materials and services from outside organizations, private companies and other government agencies to complete much of the reef development along its coast. Many significant reef construction projects have been accomplished with materials received from various road and bridge construction projects coordinated through the SCDOT. The concrete and steel materials associated with these projects have proven to be well suited to artificial reef construction.

Larger structures when mounded on the ocean bottom, as occurs when dropped from a barge, create interstitial pockets, which increase the complexity of the habitat allowing a wider diversity of organisms to flourish in the structure. For this reason it was the preference of the MARP that all materials acquired from demolition of the Cooper River Bridges should be left as intact as possible with sizes of individual structures governed by what can be safely transported and offloaded by the barges and other equipment used in the demolition. The sizes of the structures when loaded on a barge would then, in turn, dictate which reef site that particular load would go to.

Within a radius of approximately 30 miles from Charleston Harbor there are twelve offshore artificial reef sites managed by the SCDNR with allowable material profiles ranging from 10 to 35 feet above the ocean bottom. These reef locations were chosen to provide a balance between travel time for the barges, allowable placement of materials, and the number of reef sites available.

Since the placement of material, numerous underwater surveys have documented rapid colonization of the concrete and steel by invertebrates and both juvenile and adult fishes. It is expected that the increased acreage of usable habitat will lead to increased populations of numerous State and federally managed species. The South Carolina Department of Natural Resources has photographic documentation of the rapid colonization of the artificial reefs.

## QUANTITIES OF DEBRIS RECOVERED AND REUSED OR RECYCLED BY THE JOINT VENTURE

In anticipation of the large quantity of concrete and steel demolition debris that would be generated from the demolition of the Grace and Pearman bridges, the SCDNR issued a report dated November 2003 entitled "*Use of the Cooper River Bridges in the South Carolina Marine Artificial Reef Program*". The DNR report estimated that the demolition of the two bridges would generate more than 253,500 tons of structural material (Dial Cordy and Associates, 2001; HDR Engineering Inc., 2002). This amount is also presented in a PBQ&D report of September 2004 which estimated that the Grace Bridge contained 12,167 tons of steel and 79,473 tons of reinforced concrete, the Pearman Bridge contained 9,998 tons of steel and 151,923 tons of reinforced concrete, and that roughly 5% of demolition debris was expected to fall into the water. Allowing for the fact that not all portions of the bridges cross water, the report "roughly assumed" approximately 10,000 tons of reinforced concrete would fall into the river and approximately 5,000 tons would not be retrieved.

The Joint Venture removed bridge piers down to or below elevations specified. On Drum Island, other debris consisting of large parts of reinforced concrete girders from bridge structures sank partially into the ground when they were cut and fell to earth. It was subsequently agreed with the State Ports Authority, owner of Drum Island, that those girders would be cut off and removed down to a minimum depth of 2 feet below ground surface. Calculations of the volume of girders removed and girders remaining show that approximately 716 cubic yards (22%) of girders were totally removed, 525 cubic yards (16%) of reinforced girders were allowed to remain and an additional 1,983 cubic yards (62%) of cut-off girders were removed from Drum Island. The removed girder debris was included with the debris placed in reefs. The weight of remaining girder sections on Drum Island is approximately 1,063 tons.

The Joint Venture's proposal included the placement of 2,000 tons of steel bridge parts in off-shore reefs, in addition to concrete. Barge trip records show that an estimated 240,292 tons of steel-reinforced concrete debris were placed by the Joint Venture in off-shore marine artificial reefs and 5,286 tons were placed at the artificial reef adjacent to the new observation pier at Mount Pleasant, for a total of 245,578 tons. This amount of reinforced concrete would contain well in excess of 2,000 tons of reinforcing steel. It is important to note that the amounts are based on measurements that include some margin of error. These estimates do not include asphalt paving and other wastes unsuitable for placement at reefs or recycling, such as demolished wooden bridge fenders

that were characterized and properly disposed of by the Joint Venture.

There is close agreement between the original estimates provided in the SCDNR Report (more than 253,500 tons of structural material), and the actual estimated tonnage of material provided for artificial reefs (245,578 tons), differing by approximately 3.2%. This suggests that a very large percentage of the total concrete and steel debris was recovered and reused or recycled. Those portions of the bridges that were over land were entirely removed and recovered, including footers, down to or below elevations specified by the SCDOT. The land Right of Way has been cleaned up and converted to other uses. The only significant amounts of construction debris known to remain are approximately 1,063 tons of girders buried on Drum Island, and **56** tons of debris permitted to remain below the new observation pier at Mount Pleasant.

SCDOT project specifications required the demolition contractor to conduct a pre-demolition survey and a post-demolition survey of the river bottom, and submit the results to the SCDOT for review to demonstrate that the river is free of all bridge demolition debris, except for an amount of material judged to be too small or disbursed to retrieve. The limits of the survey were approximately 100 feet north of the Grace Bridge and 100 feet south of the Pearman Bridge, and extended the full width of the river, excluding Drum Island and tidal wetlands. The results of these surveys show that the overall level of clean up is better than anticipated.

The Cooper River Bridges play a significant role in not only the Charleston skyline, but also the character of the city. For good and bad, these bridges affected the lives of most Charleston area residents. Because of these deep rooted memories, it was decided by the SCDOT to require that a memorabilia program part of the demolition contract. This memorabilia program involved both the Town of Mount Pleasant and the City of Charleston.

For the Town of Mount Pleasant, several actions were taken to preserve the posterity of the Grace Memorial Bridge. Many sections of railing from the structure as well as a large section of the truss were set aside, lead abated, and repainted. These pieces one day will be fixtures in the World War II Memorial Park that the Town is currently constructing.

For the City of Charleston, it was decided that a concrete pier from the Pearman Bridge would be left standing as a monument to the structure. There was also a structural steel pier from the Grace Bridge that was set aside for a monument as well. Due to the structural issues involved leaving this steel pier in place, it was decided to performed lead abatement and repainting operations on this pier and store until appropriate measures could be taken for displaying this object.

In addition to these programs, memorabilia coins were also created out of steel from both bridges. The newly constructed Ravenel Bridge will also play a role in this unique program. Since state legislation has passed to name each tower from the new cable stayed bridge after each of the old bridges, it was decided to create silhouettes of the old bridges from salvaged steel and adorn them to the respective towers. A commemorative plaque will adorn the tower giving recognition to those who both built and dismantled the Grace and Pearman Bridges. These actions will ensure that the historical role these bridges had in the growth of Coastal South Carolina is never forgotten.

## CONCLUDING THOUGHTS

The 245,578 tons of reinforced concrete placed in artificial reefs was the largest amount of demolition debris placed in artificial reefs by any single project in South Carolina history. Also, records show that the Joint Venture sold 24,668 tons of structural steel to be recycled by the steel industry. Therefore, approximately 270,246 tons of reinforced concrete and structural steel were recovered, reused, and recycled by the Joint Venture. This project also included the largest number of reef deployments (50), and enhanced the largest number of reef sites of any project in South Carolina's history. The magnitude of this project, close agreement between the amounts of material contained in the bridges and the amounts that were recovered, reused, and recycled, and the continuity of leadership and partnership throughout the project marks this as the largest and most successful reef construction project in the history of South Carolina.

### References:

*Replacement of the Cooper River Bridges on US 17 Over the Cooper River and Town Creek Charleston, County South Carolina, Re-evaluation of the FEIS*, US Department of Transportation, Federal Highway Administration, and the South Carolina Department of Transportation, June 29, 2001.

*Use of the Cooper River Bridges in the South Carolina Marine Artificial Reef Program*, Office of Fisheries Management, Marine Resources Division, South Carolina Department of Natural Resources, November 14, 2003.

*Demolition of the Grace Memorial Bridge and the Silas N. Pearman Bridge, Charleston County South Carolina*, HDR Engineering Inc., December 16, 2003.

*Replacement of the Cooper River Bridges on US 17 Over the Cooper River and Town Creek Charleston, County South Carolina, Demolition Re-evaluation, Federal Highway Administration, and the South Carolina Department of Transportation, September 30, 2004.*

*Letter from the SCDOT to U.S. Coast Guard Marine Safety Office, Charleston, Regarding Demolition of Grace Memorial and Silas Pearman Bridges, November 17, 2004.*

*DEPARTMENT OF THE ARMY PERMIT No: 2004-1W-323, PERMITTEE: SC Department of Transportation, Columbia, South Carolina 29202, US Army Corps of Engineers, February 8, 2005.*

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In addition to providing services for Section 401 and 404 environmental permit applications and modifications, procedures for creating artificial reefs using reinforced concrete demolition debris, Earth Tech's involvement with this project included providing services for designing the reconnection of city streets and I-26/US 17 interchange improvements, characterization and disposal plans for wastes, designing a created wetlands, writing spill prevention and sediment and erosion control plans, threatened and endangered species identification, and to document satisfactory cleanup in sensitive areas. Earth Tech was also tasked with documentation that all piers were removed down to contractual elevations, and preparation of a final report to certify project cleanup.